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Forest Health Protection
Pacific Southwest Region

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To: District Ranger, Sierraville Ranger District, Tahoe National Forest

Subject: Insect and Disease Evaluation of the Silvicultural Certification Stand #4100 within the Saddle project (FHP Report NE11-02)

At the request of Beth Stewart, Silviculturist, Vegetation Management Solutions, Danny Cluck, Forest Health Protection (FHP) Entomologist, and Bill Woodruff, FHP Plant Pathologist, conducted a field evaluation of her silvicultural certification stand (stand #4100 within the Saddle project) on September 21, 2011. The objective was to evaluate the current forest health conditions within the stand, discuss what influence these conditions would have on stand management objectives and provide recommendations as appropriate. Beth Stewart accompanied us to the field.

Site information

Stand #4100 is located on Calpine Summit (Hwy 89) about 3 miles northwest of Calpine, CA at an elevation of 5500 feet (39° 41.1878"N and 120° 28.7432"W). Annual precipitation is between 30 and 40 inches and the site index is between a Dunning 3 and 4. This certification stand is a Sierra Nevada mixed conifer type with white fir (*Abies concolor*) being the dominant species and accounting for > 50% of the stand. Jeffrey pine (*Pinus jeffreyi*), ponderosa pine (*Pinus ponderosa*), lodgepole pine (*Pinus contorta var. murrayana*), sugar pine (*Pinus lambertiana*), Douglas-fir (*Psuedotsuga menziesii*) and incense cedar (*Calocedrus decurrens*) are all present in lower numbers within the stand. Species other than white fir and incense cedar are

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found mostly in the mid and overstory layers as regeneration of shade intolerant species are limited by dense canopy cover. However, some healthy pine regeneration exists in old mortality pockets where previous bark beetle activity killed groups of pine and white fir. The stand is currently overstocked at a stand density index (SDI) of 454, which is 101% of the SDI maximum of 450 determined for this conifer type (pine dominated mixed conifer). This area was selectively logged at least twice in the early to mid 1900's removing many of the larger diameter pine and cedar. This historic harvest activity combined with fire suppression, has resulted in the current white fir dominated stand conditions. Management objectives for this stand are to reduce tree density and create spatial and structural variability through mechanical thinning. Desired conditions for the area include stands that are more fire-adapted and resilient to disturbance and serve as an integral part of the defensive fuel profile zone or DFPZ network.

Forest insect and disease conditions

Sooty mold (*Arthrobotryum spongiosum*) was observed on young incense cedar which also indicates the presence of the incense-cedar scale (*Xylococculus macrocarpae*). The scale excretes honeydew that is colonized by the sooty mold.

Incense cedar rust (*Gymnosporangium libocedri*) and incense cedar true mistletoe (*Phoradendron juniperinum subsp. libocedri*) were both observed on this species throughout the stand.

Older groups of downed Jeffrey pine were observed indicating that high levels of Jeffrey pine beetle (*Dendroctonus jeffreyi*) caused mortality occurred in this stand after the 1987-1992 drought.

White fir dwarf mistletoe (*Arceuthobium abietinum f. sp. concoloris*) is present throughout the stand in both overstory and understory white fir.

Figure 1. Dead and top-killed white fir within a heterobasidion root disease center.

Heterobasidion root disease (*Heterobasidion occidentalis*, formerly referred to as S-type annosus root disease) centers are located throughout the stand as indicated by the presence of conks in old white fir stumps, stunted leader growth of infected trees and recent top-kill and whole tree mortality (Figure 1).

Recent white fir mortality caused by the fir engraver beetle (*Scolytus ventralis*) is present within and adjacent to this stand. Many of these recently killed trees were also infected with dwarf mistletoe and heterobasidion root disease (Figure 2).

Figure 2. White fir mortality caused by the fir engraver beetle.

White pine blister rust (*Cronartium ribicola*) was observed in sugar pine causing branch flagging and top-kill.

Stand conditions and mortality related to recent and future climate trends

Stand #4100 is in an overstocked condition with high numbers of disease infected white fir. These conditions combined with the recent extended dry period (2007-2009) are resulting in high levels of fir engraver beetle caused white fir mortality. These stand conditions and resulting mortality are not only restricted to this stand as adjacent areas are also affected. Pine species in this area, although not currently under attack, are also highly susceptible to bark beetle attacks and subsequent tree mortality due to the overstocked stand conditions. Evidence of past mortality of Jeffrey pine is present within the stand in the form of large older group kills. It appears, based on the deterioration of snags and down logs, that these pockets of trees were killed by Jeffrey pine beetle towards the end of the 1987 - 1992 drought.

White fir mortality has increase over the past three years throughout northeastern California as a result of drier than normal conditions. For example, the Palmer Hydrological Drought Index (PHDI) for Sierra Cascade Division, which encompasses the area of Calpine Summit, has registered moderate drought conditions each year for 2007 – 2009 (Table 1).

Table 1. Palmer Hydrological Drought Index (PHDI) 2007 - 2010, Water Year (Oct-Sept), California Division 2 (Sierra Cascade)

YEAR	PHDI
2007	-2.64
2008	-2.71
2009	-2.52
2010	0.14

*PHDI values ranging from -2.00 to -2.99 are considered moderate drought conditions. Severe drought conditions range from -3.00 to -3.99 and extreme drought conditions are below -4.00.

White fir that succumb to fir engraver beetle attacks are typically predisposed by other factors that compromise their health and vigor. In the Calpine Summit area, high stand density (in some areas), prolonged drought and heterobasidion root disease are all contributing factors in declining tree health. White fir trees in stand #4100 will remain susceptible to high levels of mortality until the current drought conditions subside. More top kill and additional whole tree mortality should be expected next summer due to fir engraver beetle attacks sustained in 2010. If the area receives normal to above normal precipitation this winter, some white fir may be able to replenish their defense systems and resist further attacks. Some trees will require more than one season with adequate moisture before they will fully recuperate their natural defenses, assuming they are free of disease.

Calpine Summit's average annual precipitation of 30 – 40" put white fir at a moderate risk to mortality without factoring in stand density and disease (D. Schultz 1994, FHP Report 94-2). Therefore, even with lower stocking levels, white fir growing on this site is at an elevated risk for fir engraver beetle caused mortality. High stand density combined with the last prolonged drought (1987-1992) resulted in elevated levels of white fir mortality throughout the project area as evidenced by older dead and down stems from that period.

Predicted climate change is likely to impact trees growing in this stand over the next 100 years. Although no Tahoe National Forest specific climate change models are available at this time, there is a general consensus among California models that summers will be drier than they are currently. This prediction is based on the forecasted rise in mean minimum and maximum temperatures and remains consistent regardless of future levels of annual precipitation (C. Mallek and H. Safford, *A summary of current trends and probable future trends in climate and climate driven processes in the Eldorado and Tahoe National Forests and the neighboring Sierra Nevada*, unpublished report, 2010). The risk of bark beetle caused tree mortality will likely increase for all conifer species under this scenario, especially drought intolerant white fir. Improving the resilience of stands to future disturbance events through density, size class and species composition management will be critical to maintaining a healthy forested landscape.

Considerations for thinning treatments

The thinning alternative being considered for this certification stand will reduce stocking to an average basal area of 120 to 140 sq.ft./acre while attempting to maintain average canopy cover at 40%. This prescription will meet the requirements of a DFPZ and be consistent with past direction from the Regional Forester to thin to “ensure that density does not exceed an upper limit (for example: 90% of normal basal area, or 60% of maximum stand density index)” and to “design thinnings to ensure that this level will not be reached again for at least 20 years after thinning.” (Regional Forester letter, “Conifer Forest Density Management for Multiple Objectives”, July 14, 2004). This treatment should effectively reduce inter-tree competition for limited water and nutrients and reduce the risk of insect and disease caused mortality.

Since this stand is within a higher canopy cover requirement management area, it will likely be necessary to try and maintain a higher stand density, closer to the upper management limit, which may require more frequent entries than the 20 year recommendation. If canopy cover requirements do not allow for a reduction in stand density that increases the health and vigor of residual trees, the risk for bark beetle caused mortality will remain high, especially during prolonged periods of drought. Failure to reduce the risk of bark beetle caused mortality could result in significant mortality and reduce canopy cover below the desired future condition.

When planning thinning treatments, it should be recognized that the target stand density is an average to be applied across the landscape and some variability may be desired. Individual high value trees, such as mature pines, should benefit by having the stocking around them reduced to lower levels. Areas of pure or nearly pure ponderosa and Jeffrey pine would also benefit from lower stocking levels as well as an increase in species diversity. Allowing for denser tree spacing and pockets of higher canopy cover may be desirable around potential wildlife trees, such as forked and/or broken-topped trees. This type of ecological restoration approach would also be consistent with the Region 5 Ecological Restoration Strategic Priority.

When implementing thinning projects, retaining more drought tolerant species such as ponderosa pine and Jeffrey pine over white fir will increase species diversity and make stands more resilient to disturbance. In addition, when selecting trees for removal, preference should be given to trees heavily infected with dwarf mistletoe, root disease and trees infested with bark beetles. Small group selections could be utilized to remove white fir that are within known heterobasidion root

disease centers and/or are heavily infected with dwarf mistletoe. This would create openings that could be planted with non-host species.

It is recommended that a registered borate compound be applied to all freshly cut pine stumps >14" dbh to reduce the chance of creating new infection centers of *Heterobasidion irregulare*, formerly referred to as S-type annosus root disease, through harvest activity. Since it appears that *Heterobasidion occidentalis* is already present in throughout the stand, the treatment of white fir stumps is not as critical and can be reserved for areas that appear to be free of root disease.

Radial thinning around large diameter old growth pines should also be considered to further increase their growth and vigor. Removing competing trees within approximately 50 feet of large diameter pines combined with stand level thinning has resulted in a measured increase in annual increment growth in old growth ponderosa and Jeffrey pine on the Lassen National Forest (FHP unpublished data).

Special consideration needs to be given to sugar pine in the Calpine Summit unit. Sugar pine should be retained as much as possible during any thinning operation in order to preserve genetic diversity, especially white pine blister rust (*Cronartium ribicola*) resistant individuals. White pine blister rust, a non-native pathogen, has continued to weaken and kill this species over most of its range since its introduction into the Pacific Northwest in 1910. Two rust resistant sugar pines are located within the stand. These trees should have all competing vegetation and fuels removed from their immediate area, including the removal of larger trees that are crowding the rust resistant sugar pine. In addition, planting openings created by any group selection harvest with rust resistant stock would help insure this species persists in the area.

Infection of incense cedar by incense cedar rust and incense cedar true mistletoe would generally not result in tree mortality during periods of normal to above normal precipitation as this disease rarely causes any more injury than scattered dieback of small branches. However, when combined with moisture stress, these trees are at a slightly higher risk to drought caused mortality than uninfected trees. To reduce future mortality, select heavily infected trees (trees with excessive brooms) for removal during thinning operations. Bark scale insects and sooty mold are not a management concern for incense cedar.

Figure 3. Scouler's willow skeleton under a canopy of white fir and incense cedar.

Scouler's willow (*Salix scouleriana*), a shade intolerant species, is present in one of the dry stream beds that intersects the stand and is being overtopped by competing conifers (mostly white fir and incense cedar) resulting in the mortality of many individual clumps (Figure 3). To preserve and enhance the growing conditions for this hardwood species, and improve overall stand and fuels conditions, thinning through this drier riparian corridor similar to the upland portions of the stand is recommended and also supported

by recent research. (K. Van de Water and M. North, *Fire history of coniferous riparian forests in the Sierra Nevada*, Forest Ecology and Management, 2010).

Considerations for prescribed fire

If prescribed fire is used as a follow-up treatment to stand thinning, unacceptable levels of large diameter pine mortality may occur depending on management objectives. This mortality most often occurs as a direct result of cambium or crown injury to individual trees during the fire. Mature Jeffrey, ponderosa and especially sugar pines are susceptible to mortality during prescribed burns because of the deep duff and litter that has accumulated at their base in the absence of fire. These duff mounds typically burn at a slow rate, while maintaining lethal temperatures, causing severe cambium injury. To protect individual large diameter pine from lethal cambium injury, raking the duff away from the bases of these trees before burning (within 24" of the bole and down to mineral soil) is recommended.

Potential for hazard trees

This stand contains a large National Forest boundary sign (dividing the Plumas and Tahoe National Forests) adjacent to Highway 89. As a result, the public has created an informal parking area. It is likely that forest visitors are stopping to take pictures with the sign, walk the surrounding forest and take lunch under nearby trees. This brings up the issue of hazard trees, especially with the presence of *Heterobasidion occidentale* in nearby white fir. To abate potential hazards, white fir with signs of root disease infection should be removed from this area. To assess trees for root disease, it is reasonable to use the condition of the crown as an indicator of advanced decay. Although not always caused by root decay, a thin crown does indicate poor tree vigor. A tree with reduced photosynthesis is not able to maintain healthy roots as well as a tree with a full and healthy crown. In the presence of root disease, unhealthy roots will likely be overcome with decay faster than vigorously growing roots. For this reason, the thinner the crown of a tree in an area where root disease is present, the more likely it is that the roots have been weakened by decay.

If you have any questions regarding this report and/or need additional information please contact Danny Cluck at 530-252-6431 or Bill Woodruff at 530-252-6680.

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<u>Appendix A – Insect and Disease Information</u>

Fir Engraver

The fir engraver attacks red and white fir in California. Fir engraver adults and developing broods kill true firs by mining the cambium, phloem, and outer sapwood of the bole, thereby girdling the tree. Trees greater that 4" in diameter are attacked and often killed in a single season. Many trees, weakened through successive attacks, die slowly over a period of years. Others may survive attack as evidenced by old spike-topped fir and trees with individual branch mortality. Although many other species of bark beetles cannot develop successful broods without killing the tree, the fir engraver beetle is able to attack and establish broods when only a portion of the cambium area has been killed.

Evidence of Attack

Fir engravers bore entrance holes along the main stem, usually in areas that are > 4" in diameter. Reddish-brown or white boring dust may be seen along the trunk in bark crevices and in spider webs. Some pitch streamers may be indicative of fir engraver attacks; however, true firs are known to stream pitch for various reasons and there is not clear evidence that pitch streamers indicate subsequent tree mortality or successful attack. Resin canals and pockets in the cortex of the bark are part of the trees defense mechanism. Beetle galleries that contact these structures almost always fail to produce larval galleries as the adults invariably abandon the attack. Pitch tubes, often formed when bark beetles attack pine, are not produced on firs.

Adults excavate horizontal galleries that engrave the sapwood; the larval galleries extend at right angles along the grain. Attacks in the crown may girdle branches resulting in individual branch mortality or "flagging". Numerous attacks over part or the entire bole may kill the upper portion of the crown or the entire tree. A healthy tree can recover if sufficient areas of cambium remain and top-killed trees can produce new leaders. The fir engraver is frequently associated with the roundheaded fir borer and the fir flatheaded borer.

Life Stages and Development

In the summer, adults emerge and attack new host trees. The female enters the tree first followed by the male. Eggs are laid in niches on either side of the gallery. Adult beetles carry the brown staining fungi, *Trichosporium symbioticum*, into the tree that causes a yellowish-brown discoloration around the gallery. The larvae mine straight up and down, perpendicular to the egg gallery. Winter is commonly spent in the larval stage, with pupation occurring in early spring. In most locations, the fir engraver completes its life cycle in 1 year, however at higher elevations 2 years may be required.

Conditions Affecting Outbreaks

Fir engravers bore into any member of the host species on which they land but establish successful galleries only in those that have little or no resistance to attack. Populations of less aggressive species like fir engraver are likely to wax and wane in direct relationship to the stresses of their hosts. Drought conditions often result in widespread fir mortality; however, attempting to determine when outbreaks will occur is difficult. Lowered resistance of trees appears to be a contributing factor. Overstocking and the increased presence of fir on sites that were once occupied by pine species may also contribute to higher than normal levels of fir mortality. Several insect predators, parasites and woodpeckers are commonly associated with the fir engraver and may help in control of populations at endemic levels.

Heterobasidion Root Disease (formerly Annosus Root Disease)

Heterobasidion spp. is a fungus that attacks a wide variety of woody plants. All western conifer species are susceptible. Madrone (*Arbutus menziesii*), and a few brush species (*Arctostaphylos spp.* and *Artemisia tridentata*) are occasional hosts. Other hardwood species are apparently not infected. The disease has been reported on all National Forests in California, with incidence particularly high on true fir in northern California, in the eastside pine type forests, and in southern California recreation areas.

Heterobasidion root disease is one of the most important conifer diseases in Region 5. Current estimates are that the disease infests about 2 million acres of commercial forestland in California, resulting in an annual volume loss of 19 million cubic feet. Other potential impacts of the disease include: increased susceptibility of infected trees to attack by bark beetles, mortality of infected trees presently on the site, the loss of the site for future production, and depletion of vegetative cover and increased probability of tree failure and hazard in recreation areas.

During periods favorable to the fungus, fruiting bodies (conks) form in decayed stumps, under the bark of dead trees, or under the duff at the root collar. New infection centers are initiated when airborne spores produced by the conks land and grow on freshly cut stump surfaces. Infection in true fir may also occur through fire and mechanical wounds, or occasionally, through roots of stumps in the absence of surface colonization. From the infected stump surface, the fungus grows down into the roots and then spreads via root-to-root contact to adjacent live trees, resulting in the formation of large disease centers. These infection centers may continue to enlarge until they reach barriers, such as openings in the stand or groups of resistant plants. In pines, the fungus grows through root cambial tissue to the root crown where it girdles and kills the tree. In true fir and other non-resinous species, the fungus sometimes kills trees, but more frequently is confined to the heartwood and inner sapwood of the larger roots. It then eventually extends into the heartwood of the lower trunk and causes chronic decay and growth loss.

Heterobasidion root disease in western North America is caused by two species: *Heterobasidion occidentalis* (also called the 'S' type) and *H. irregularis* (also called the 'P' type). These two species of *Heterobasidion* have major differences in host specificity. *H. irregularis* (‘P’ type) is pathogenic on ponderosa pine, Jeffrey pine, sugar pine, Coulter pine, incense cedar, western juniper, pinyon, and manzanita. *H. occidentalis* (‘S’ type) is pathogenic on true fir, spruce and giant sequoia. This host specificity is not apparent in isolates from stumps; with *H. occidentalis* being recovered from both pine and true fir stumps. These data suggest that infection of host trees is specific, but saprophytic colonization of stumps is not. The fungus may survive in infected roots or stumps for many years. Young conifers established near these stumps often die shortly after their roots contact infected roots in the soil.

Dwarf Mistletoe

Dwarf mistletoes (Arceuthobium spp.) are parasitic, flowering plants that can only survive on living conifers in the Pinaceae. They obtain most of their nutrients and all of their water and minerals from their hosts.

Dwarf mistletoes spread by means of seed. In the fall the fruit ripen and fall from the aerial shoots. The seeds are forcibly discharged. The seed is covered with a sticky substance and adheres to whatever it contacts. When a seed lands in a host tree crown, it usually sticks to a needle or twig, where it remains throughout the winter. The following spring the seed germinates and penetrates the

twig at the base of the needle. For the next 2-4 years, the parasite grows within the host tissues, developing a root-like system within the inner bark and outer sapwood, and causing the twig or branch to swell. Aerial shoots then develop and bear seed in another 2-4 years.

Dispersal of dwarf mistletoe seeds is limited to the distance the seeds travel after being discharged. From overstory to understory, this is usually 20 to 60 feet, but wind may carry them as far as 100 feet from the source. A rule of thumb is that the seeds can travel a horizontal distance equal to the height of the highest plant in an infected tree. There is some evidence that long distance spread of dwarf mistletoe is occassionaly vectored by birds and animals.

Vertical spread within tree crowns of most dwarf mistletoes is limited to less than one foot per year because of foliage density. Because of the thin crowns of gray pine, however, the vertical rate of spread has been measured as being greater than 2 feet per year. This rate of spread equalled or exceeded the rate of height growth of infected trees.

Dwarf mistletoes are easy to identify because they are generally exposed to view within a tree's crown. Signs of infection include the yellow-green to orange mistletoe plants, basal cups on a branch or stem where the plants were attached and detached plants on the ground beneath an infected tree. Symptoms include spindle-shaped branch swellings, witches' brooms in the lower crown, and bole swellings.

White pine blister rust

White pine blister rust is caused by Cronartium ribicola an obligate parasite that attacks 5-needled pines and several species of Ribes spp. The fungus needs the two alternate hosts to survive, spending part of its life on 5-needled pines and the other on Ribes spp. The disease occurs throughout the range of sugar pine to the southern Sierra Nevada, but has not been reported further south. Infection of pines results in cankers on branches and main stems, branch mortality, top kill, and tree mortality.

Spores (aeciospores) produced by the fungus in the spring on pine bole or branch cankers are wind-disseminated to Ribes spp. where they infect the leaves. Spores (urediospores) produced in orange pustules on the underside of the leaves reinfect other Ribes spp. throughout the summer, resulting in an intensification of the rust. A telial spore stage forms on Ribes spp. leaves in the fall. Teliospores germinate in place to produce spores (sporida) which are wind-disseminated to pines and infect current year needles. Following infection, the fungus grows from the needle into the branch and forms a canker. After 2 or 3 years, spores are produced on the cankers and are spread to Ribes spp. to continue the cycle. Although blister rust may spread hundreds of miles from pines to Ribes spp., its spread from Ribes spp. back to pines is usually limited to a few hundred feet.

Branch cankers continue to enlarge as the fungus invades additional tissues and moves toward the bole. Branch cankers within 24 inches of the bole will eventually form bole cankers. Bole cankers result in girdling and death of the tree above the canker. Cankers that have margins more than 24 inches from the main bole are unlikely to reach the bole and only branch flagging will result.